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<div style="display: flex; justify-content: space-between;"> <div style="width: 48%; vertical-align: top;"> <p>(21) International Application Number: PCT/GB00/00286</p> <p>(22) International Filing Date: 2 February 2000 (02.02.00)</p> <p>(30) Priority Data: 9902584.3 8 February 1999 (08.02.99) GB</p> <p>(71) Applicant (for all designated States except US): BAE SYSTEMS PLC [GB/GB]; Warwick House, P.O. Box 87, Farnborough Aerospace Centre, Farnborough, Hampshire GU14 6YU (GB).</p> <p>(72) Inventor; and (75) Inventor/Applicant (for US only): GRAY, Ian, Lindsay [GB/GB]; BAE Systems, Building 07C, New Filton House, Filton, Bristol, Avon BS99 7AR (GB).</p> <p>(74) Agent: EDIS, Ronald, Malcolm; BAE Systems, Group IP Dept., Lancaster House, P.O. Box 87, Farnborough Aerospace Centre, Farnborough, Hampshire GU14 6YU (GB).</p> </div> <div style="width: 48%; vertical-align: top;"> <p>(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report.</i></p> </div> </div>		
(54) Title: FIBRE REINFORCED COMPOSITES AND METHOD OF MAKING SAME		
(57) Abstract <p>A method is disclosed for producing a fibre reinforced composite by pultrusion having variable strength characteristics along its length including the steps of drawing through a pultrusion die (38) a series of reinforcing fibres (32) to form a pultruded fibre composite product. The method is characterised by incorporating in the reinforcing fibres (14) prior to the pultrusion step additional fibres (20) to form modified fibres (32) having a characteristic such as tenacity or modulus different from that of the first said reinforcing fibres (14) in order to vary the strength characteristics of the final composite (42) substantially without altering the cross-sectional area thereof. A curable or settable plastics material (40) is applied around the fibres during the pultrusion step and which is cured, part-cured or allowed to set to form the finished composite (42).</p>		

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FIBRE REINFORCED COMPOSITES AND METHOD OF MAKING SAME

This invention relates to fibre reinforced composites, in particular those used in high strength applications such as aircraft structures.

It is known to manufacture by pultrusion, composite structural members for use as skin stringers for aircraft wing and fuselage skins, for example. Such pultruded members are currently manufactured by drawing reinforcing fibres, such as carbon fibres, through a die, applying liquid plastics matrix material to the fibres, and curing or setting the whole to form a fibre reinforced composite structural member of the required cross-sectional shape and of indefinite length.

There exists a requirement to provide structural members such as aircraft wing or fuselage skin stringers with strength characteristics which vary along their length. It is currently proposed to provide such a member with variable cross-section in order to achieve the variation in strength required. Unfortunately such changes in cross-sectional shape for pultruded members are not easy to achieve. Currently variable shape pultrusion dies are being investigated with a view to allowing changes in cross-sectional shape of the structural member along its length. It will be appreciated that such variable cross-section dies will be somewhat complex and possibly difficult to produce. In addition their reliability and/or longevity may be limited.

According to the present invention there is provided a method of producing a fibre reinforced composite by pultrusion having strength characteristics which vary along the length of the composite, the method including the steps of drawing through a pultrusion die a series of reinforcing fibres to form a pultruded fibre composite product characterised by incorporating in the reinforcing fibres prior to the pultrusion step additional fibres, which may have a characteristic such as tenacity or modulus different from that of the said reinforcing fibres, in order to vary the strength characteristics of the final product along the said length substantially without altering

the cross-sectional area thereof, a curable or settable plastics matrix material being applied around the fibres and solidified by being cured or allowed to set to form the finished composite.

By “tenacity” is meant tensile strength per unit area of fibre. In this way a higher tenacity fibre may have a reduced cross sectional area compared with a lower tenacity fibre. By “modulus” is meant Young’s modulus for the fibre concerned.

Preferably, the additional fibres are either spliced between discrete lengths of the reinforcing fibres, or interlaced or otherwise distributed amongst continuous said reinforcing fibres.

The fibres may be pre-impregnated with the plastics material before being drawn through the protrusion die. If the fibres are not pre-impregnated then a plastics material may be introduced amongst the fibres as they are drawn through the die. Where the plastics material is curable, the pultrusion die may be heated to effect curing or part curing of the plastics material.

The fibres may be in the form of individual strands, or may form woven and/or non-woven webs.

A method in accordance with the invention will now be described by way of example, and with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic view of an apparatus for splicing fibres for use in a method in accordance with the invention;

Figure 2a is an alternative enlarged diagrammatic view of box A in Figure 1;

Figure 2b is an enlarged diagrammatic view of box A in Figure 1; and

Figure 3 is a diagrammatic view of a pultrusion apparatus for producing a fibre reinforced composite in accordance with the invention.

Figure 1 shows an apparatus for splicing fibres and comprises a substantially horizontal work bench 10, a source roll 12 of reinforcing fibres 14 and a product receiving roll 16.

Reinforcing fibres 14 are drawn off the source roll 12, across the work bench 10 and wound onto the product receiving roll 16.

Additional fibres 20 are provided which can either be spliced between lengths 26, 28 of the reinforcing fibres (Figure 2a) to provide an area 18 having a characteristic such as tenacity or modulus different from that of the fibres 14, or can be interlaced or otherwise distributed amongst the reinforcing fibres 14 (Figure 2b).

When the additional fibres 20, are spliced into the reinforcing fibres 14 as shown in Figure 2a, the ends of the fibres may either be knotted together or air blown so that the fibres become matted together to form a joint 22. It should be noted that the joint 22 so formed primarily allows continuity of the pultrusion process.

It should be further noted that it is preferable for the introduction of a change in fibre type to be phased over the predetermined area or areas 18. By phasing the introduction of the additional fibres, stress on individual joints between the fibres is spread over a greater area thus minimising stress concentration.

In Figure 2a it will be noted that the phased introduction leads to the additional fibres 20 meeting the reinforcing fibres 14 on an oblique plane 24 although it will be understood that other suitable phased introduction, e.g. a zig-zag, could be used.

The product receiving roll 16 is then transferred to a pultruding apparatus 30 as shown in Figure 3. The pultruding apparatus 30 includes supports (not shown) for a number of product receiving rolls 16. In the present example, four rolls 16 are carried by the supports. The modified fibres, indicated at 32, are drawn from the rolls 16 and aligned through guide vanes 34 and 36 so as to position them in a predetermined pattern.

The modified fibres 32 are then pulled through a pultrusion die 38. Resin 40 from a supply 41 is injected amongst the fibres 32 as they are drawn through the die 38 to produce a fibre reinforced composite 42 of substantially constant cross-sectional area. The fibre reinforced composite 42 is part drawn out through the die 38 by reciprocating caterpillar pullers 44.

Where the additional fibres 20 are distributed amongst the reinforcing fibres 14 as in Figure 2b there is a reduction in the ratio of fibre 32 to resin 40 content of the final composite 42 compared to the composition in which the fibres are spliced as shown in Figure 2a.

The fibres 32 may also be pre-impregnated with resin before drawing them through the pultrusion die 38. That may alleviate, or avoid altogether, the need to inject resin 40 amongst the fibres 32 as they are pulled through the die 38.

The fibres 32 may be in the form of a fabric, which may be woven and/or non-woven.

If the resin is curable, the pultrusion die 38 may be heated to effect curing or part curing of the resin.

In the present example, the plastics matrix material used is a resin, although it may also be any adhesive/matrix system.

The length of the predetermined area 18 along the fibres 14 can be selected as required.

The above methods enable the production of a fibre reinforced composite having variable strength characteristics along its length without alteration of the cross-sectional area of the pultruded composite.

Claims

1. A method of producing a fibre reinforced composite by pultrusion having variable strength characteristics along its length including the steps of drawing through a pultrusion die a series of reinforcing fibres to form a pultruded fibre composite product characterised by incorporating in the reinforcing fibres prior to the pultrusion step additional fibres in order to vary the strength characteristics of the final product substantially without altering the cross-sectional area thereof, a plastics matrix material being applied around the fibres and allowed to solidify to form the finished composite.
2. A method according to claim 1 in which the additional fibres have a characteristic different from that of the said reinforcing fibres.
3. A method according to claim 2 in which the said characteristic is selected from the group fibre tenacity and fibre modulus.
4. A method according to claim 1, 2 or 3 in which the additional fibres are spliced between discrete lengths of the reinforcing fibres.
5. A method according to claim 1, 2 or 3 in which the additional fibres are interlaced amongst continuous said reinforcing fibres.
6. A method according to any of claims 1 to 5 in which the plastics matrix material is applied to the fibres, within the die.
7. A method according to any of claims 1 to 5 in which the fibres are pre-impregnated with a plastics matrix material before being drawn through the die.
8. A method according to any preceding claim in which the fibres are in the form of a woven web.

9. A method according to any one of claims 1 - 7 in which the fibres are in the form of a non-woven web.
10. A composite structural member produced according to the method of any preceding claim.
11. A composite structural member according to claim 10 comprising an aircraft skin stringer.
12. An aircraft aerofoil incorporating a composite structural member according to claim 10 or 11.
13. An aircraft containing a composite produced according to the method of any of claims 1 to 9.

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Fig.1.

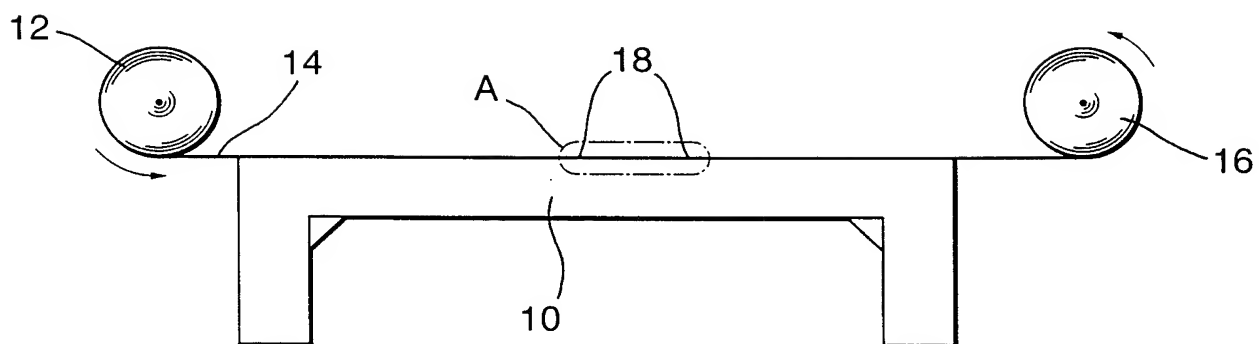


Fig.2a.

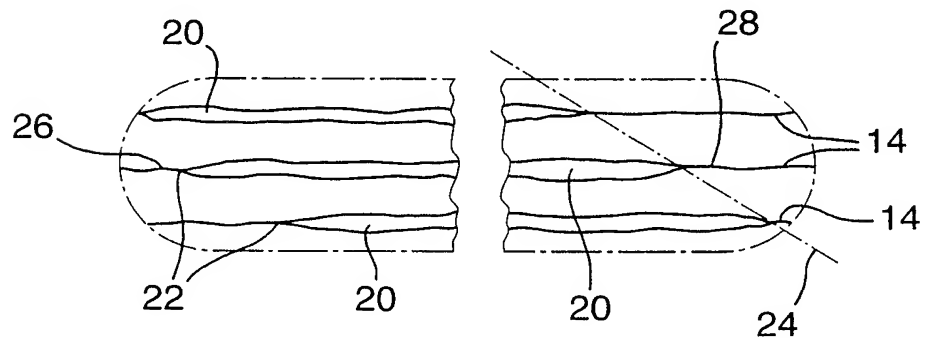


Fig.2b.

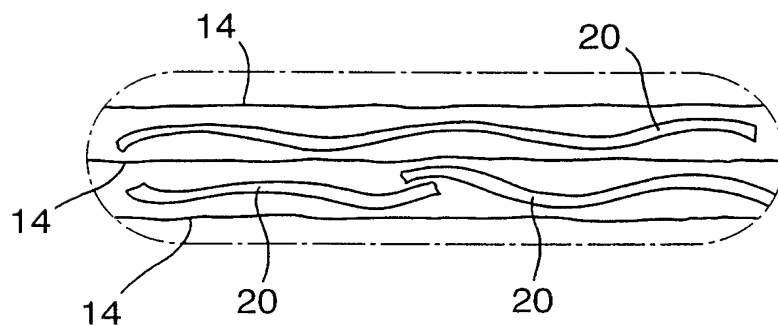
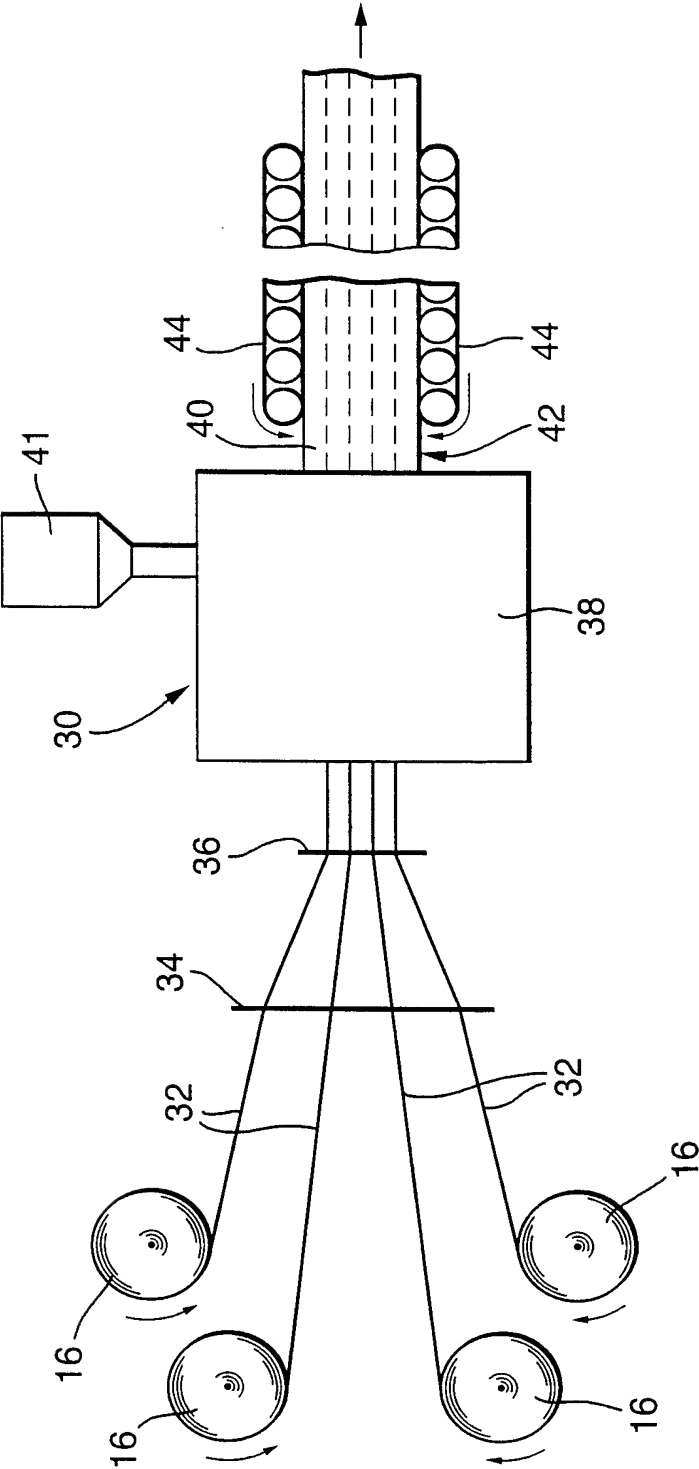


Fig.3.



INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/00286

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B29C70/52

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 439 215 A (RATCHFORD DAVID) 8 August 1995 (1995-08-08) column 4, line 33 - line 36	1,6,10
A	US 4 605 254 A (CARMEN JOSEPH A) 12 August 1986 (1986-08-12) column 5, line 56 - line 59	1-13



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search

8 May 2000

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16/05/2000

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Authorized officer

Van Wallene, A

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/00286

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5439215 A	08-08-1995	CA 2132567 A	25-07-1995
US 4605254 A	12-08-1986	US 4570988 A	18-02-1986

DERWENT-ACC-NO: 2000-571859**DERWENT-WEEK:** 200840*COPYRIGHT 2008 DERWENT INFORMATION LTD*

TITLE: Production of fiber reinforced composite used as aircraft structures, having variable strength along its length, involves incorporating additional fiber into reinforcing fiber prior to pultrusion

INVENTOR: GRAY I L; GRAY I L B S**PATENT-ASSIGNEE:** BAE SYSTEMS PLC[BRAX] , AIRBUS UK LTD[AIRBN]**PRIORITY-DATA:** 1999GB-002584 (February 8, 1999)**PATENT-FAMILY:**

PUB-NO	PUB-DATE	LANGUAGE
WO 0047397 A1	August 17, 2000	EN
AU 200021219 A	August 29, 2000	EN
EP 1150828 A1	November 7, 2001	EN
JP 2002534295 W	October 15, 2002	JA
EP 1150828 B1	July 23, 2003	EN
DE 60004012 E	August 28, 2003	DE
ES 2203416 T3	April 16, 2004	ES
JP 4097899 B2	June 11, 2008	JA

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CZ DE DK DM EE ES FI GB GD GE GH GM HR HU ID IL
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BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL
PT SE AT BE CH CY DE DK ES FI FR GB GR IE IT LI
LU MC NL PT SE

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
WO2000047397A1	N/A	2000WO-GB00286	February 2, 2000
AU 200021219A	N/A	2000AU-021219	February 2, 2000
DE 60004012E	N/A	2000DE-604012	February 2, 2000
EP 1150828A1	N/A	2000EP-901265	February 2, 2000
EP 1150828B1	N/A	2000EP-901265	February 2, 2000
JP2002534295W	N/A	2000JP-593078	February 2, 2000
JP 4097899B2	N/A	2000JP-593078	February 2, 2000
EP 1150828A1	N/A	2000WO-GB00286	February 2, 2000
JP2002534295W	N/A	2000WO-GB00286	February 2, 2000
EP 1150828B1	N/A	2000WO-GB00286	February 2, 2000
DE 60004012E	N/A	2000WO-GB00286	February 2, 2000
JP 4097899B2	Based on	2000WO-GB00286	February 2, 2000

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CIPP	B64C1/00 20060101
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CIPS	B29C70/52 20060101
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CIPN	B29L31/30 20060101

ABSTRACTED-PUB-NO: WO 0047397 A1

BASIC-ABSTRACT:

NOVELTY - Production of fiber reinforced composite having variable strength along its length, involves incorporating additional fiber into reinforcing fiber (RF) such that the strength of final product is varied without altering its cross-sectional area. A series of RF is drawn through a die to form a pultruded fiber composite product. A plastic matrix material is applied around the fibers and allowed to solidify.

DESCRIPTION - An INDEPENDENT CLAIM is also included for the composite structural member.

USE - As skin stringers, aircraft aerofoil incorporating composite structural member (claimed) and fuselage skins.

ADVANTAGE - The strength of fiber reinforced composite products is varied without altering its cross sectional area. The fiber reinforced composites can be effectively used in high strength applications such as air craft structures.

EQUIVALENT-ABSTRACTS:

TEXTILES AND PAPER

Preferred Process: The fibers in the form of (non-)woven web, are pre-impregnated with plastic matrix material before being drawn to the die.

Preferred Property: The group fiber tenacity and fiber modulus properties of additional fiber are different from reinforcing fibers. Preferred Arrangement: The additional fibers are spliced between discrete lengths of RF or interlaced amongst continuous RF.

TITLE-TERMS: PRODUCE REINFORCED COMPOSITE AIRCRAFT STRUCTURE
VARIABLE STRENGTH LENGTH INCORPORATE ADD PRIOR
PULTRUSION

DERWENT-CLASS: A32 A95 Q25

CPI-CODES: A11-B09A1; A12-T02;

ENHANCED-POLYMER-INDEXING: Polymer Index [1.1] 018 ; P0000; K9892;

Polymer Index [1.2] 018 ; ND07; N9999
N6064 N6042; Q9999 Q9223 Q9212; Q9999
Q9289 Q9212; B9999 B4091*R B3838 B3747;

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S9999 S1070*R; A999 A771; S9999
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SECONDARY-ACC-NO:

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